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Geohazard features of the Aeolian Island slopes and the North-Eastern Sicily offshore

Fabiano Gamberi [a], Daniele Casalbore[b], Michael Marani[a], Marzia Rovere[a], Alessandro Bosman[b], Marilena Calarco[b], Giacomo Dalla Valle[a], Elisa Leidi[a], Eleonora Martorelli[b], Alessandra Mercorella[a], Martina Pierdomenico[b], Claudia Romagnoli[c], Chiara Adami[b], Francesco Giuseppe Falese[b], Andrè Fascetti[b], Valentina Ferrante[a], Michela Ingrassia[b], Erika Lai[b], Cristian Montanaro[b], Andrea Sposato[b] and Francesco Latino Chiocci[a]

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ABSTRACT
The MaGIC project (Marine Geohazard along the Italian Coasts) had the aim of mapping the geohazard in the Italian seas and resulted in the production of numerous maps covering parts of the Italian Seas. In this paper, we present the maps: 'The submerged portions of the Aeolian volcanic islands and the north-eastern Sicilian margin', located in the south-eastern Tyrrhenian Sea. Both areas are affected by active geological processes, which represent important geohazards elements. Inthe submarine parts of the Stromboli volcanoremobilization of volcaniclastic deposits occur along the Sciara del Fuoco, where small-scale instabilities may represent a source of geohazard. Hydrothermal activity occurs on Enarete and Enaretino conical seamounts. The north-eastern Sicilian margin has a narrow continental shelf. Numerous canyon heads indent the shelf and, sometimes, reach close to the coast. Canyons have often a retrogradational trend and further eventual landward shift through sliding can iendangeri coastal or offshore infrastructures. Many of the canyons connect with leveed channels with widespread sediment instability. In the Gioia Basin, some of the channels connect to form the Stromboli slope Valley. Volcanic unrest or local and regional earthquakes are proven to have caused submarine landslides and tsunamis.

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1. Introduction

Our article complements the 'Maps of Geohazard features of the eastern Sardinian Margin', produced in the frame of the MaGIC project (Marine Geohazard along the Italian Coasts) (Main Map). The latter was a large coordinated effort which involved the whole marine geological community in Italy in the years 2007–2013. The maps result from the interpretation of multibeam bathymetric data acquired during various cruises. As such, in the maps, the hazard reconstructions result from the interpretation of the seafloor morphology and of the shallow and immediate sub-surface elements. Two levels of interpretation are presented: the map of the Physiographic Domain at 1:250,000 scale and the map of the Morphological Units and Morpho-bathymetric Elements (areas and vectors respectively) at 1:100,000 scale.

2. Study area: the geology of the Aeolian Island slopes and North-Eastern Sicilian offshore

The north-eastern Sicilian margin and the Aeolian Islands sit between the Calabrian Arc and the southern Tyrrhenian back-arc basin in the context of the NW-ward subduction of the Ionian lithosphere beneath the Calabrian Arc (Doglioni, 1991; Gvirtzman & Nur, 1999; Malinverno & Ryan, 1986; Marani & Gamberi, 2004a; Figure 1(a)).

The basement Units of the Peloritani Mountains, overlay the Sicilian-Maghrebian Chain, and border the Sicilian margin (Figure 1; Lentini et al., 1996). NNE-SSW-trending normal faults and NW-SE-trending strike-slip faults cause a horst and graben structural setting.

High regional uplift rates affect the Western Calabria and the NE Sicily area (Sulli et al., 2013; Westaway,

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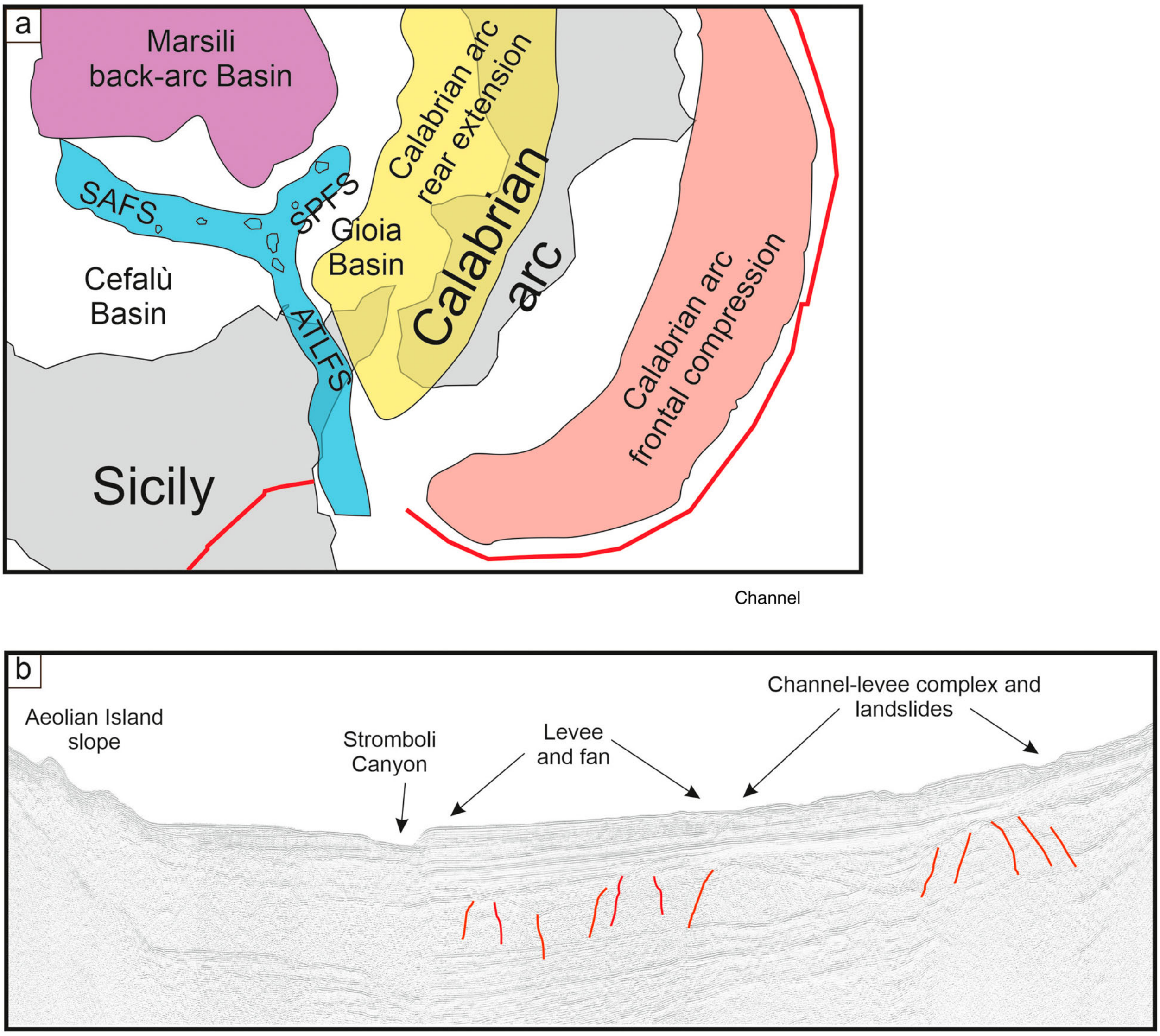

Figure 1. (a) Sketch of the regional geology of the Aeolian Arc and the north-eastern Sicilian margin (SAFS = Sisifo-Alicudi fault Syatem; ATLFS = Aeolian-Tinadari-Letojanni Fault System; SPFS = Stromboli-Panarea fault System) (modified from Barreca et al. 2014). The red line marks the external front of the Calabrian arc and the Apenninic-Maghrebian chain. (b) Sparker seismic line BG2 showing the extensional tectonic features affecting the Sicilian margin in the area of the Gioia basin. Landslide and channels are also evident. The Stromboli valley is here a depositional feature forming an extensive levee wedge. The volcaniclastic apron in the Aeolian Island slope displays chaotic reflections indicative of instability and erosional, often channelized, flows.

1993) and are modified by vertical movements connected to active tectonic structures (Catalano et al., 2003; Scicchitano et al., 2011). Short and steep watercourses (locally named 'fiumare'), with torrential regimes, drain the mountainous hinterland. They can transport large volumes of debris into the sea in a very short time span. An important seismicity, with frequent moderate to strong earthquakes, affects the area.

A very narrow continental shelf is present along the northern Sicilian margin (Gamberi, 2020; Gamberi, Rovere, et al., 2014) where some of the canyon heads reach the coastal areas (Gamberi, 2019; Gamberi et al., 2015, 2017). The distal part of deltas develops where the shelf is relatively larger (Casalbore, Ridente, et al., 2017; Distefano & Gamberi, 2022; Gamberi et al., 2015). In the slope, both constructional and destructional sectors are evident (Gamberi et al., 2019; Gamberi & Marani, 2006). In the first case, channel-levee systems develop (Gamberi, Rovere, Mercorella, & Leidi, 2014; Gamberi & Rovere, 2011), in the latter, large mass-transport complexes composed predominate (Gamberi et al., 2011, 2020; Gamberi & Marani, 2006). In the intraslope basins, frontal splay form at the mouth of submarine channels (Gamberi, 2019; Gamberi & Rovere, 2011; Gamberi, Rovere, Mercorella & Leidi, 2014). However, also landslide deposits contribute to the basin plain stratigraphy (Gamberi, 2019; Gamberi et al., 2011, 2015, 2019).

The Aeolian Arc is made up of seven islands and several seamounts: Sisifo, Enarete and Eolo to the West of Alicudi, and Lametini and Alcione to the North of Stromboli (Marani & Gamberi, 2004b; Figure

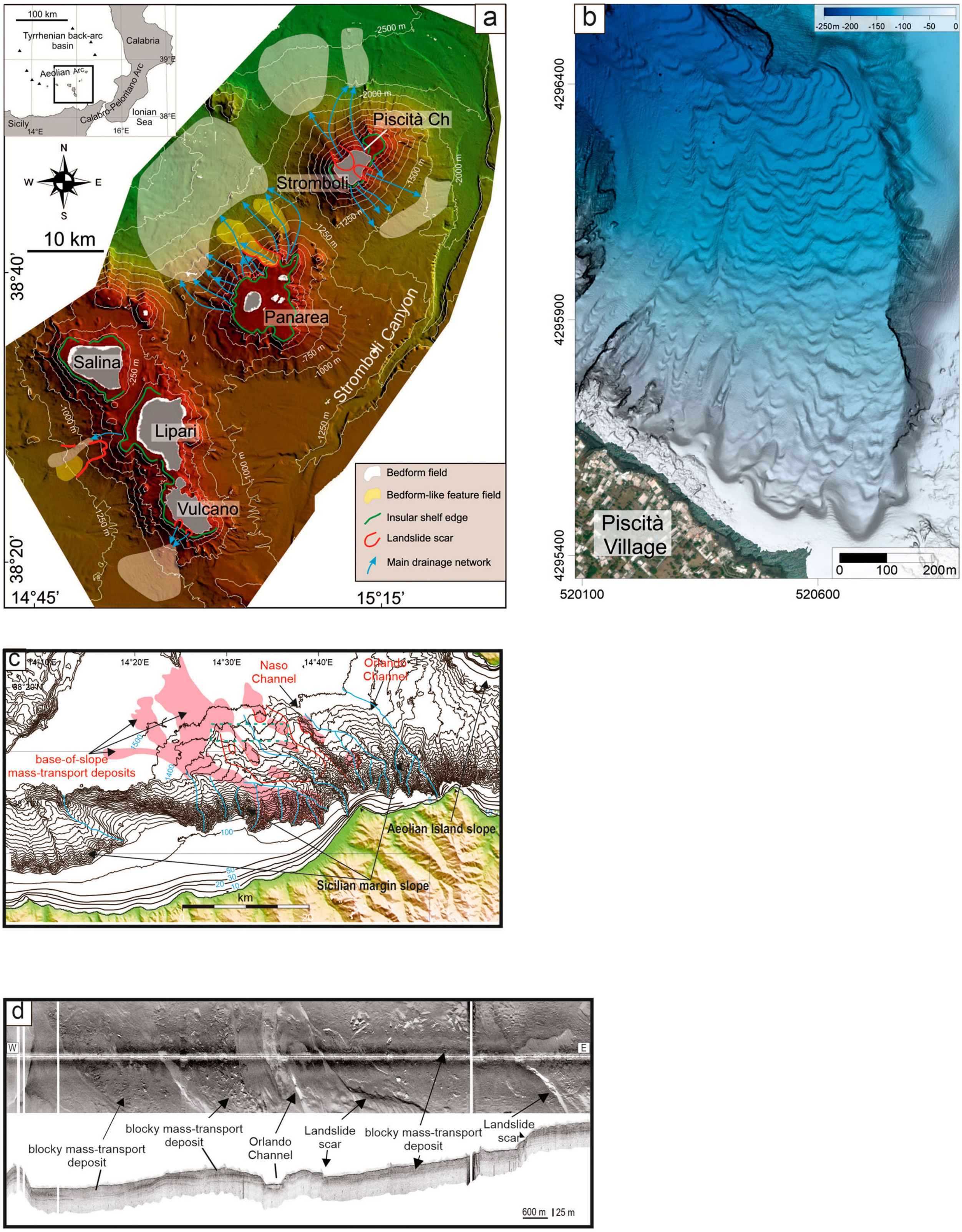

Figure 2. (a) Shaded relief map of the central and eastern sectors of the Aeolian Archipelago. Channels and gullies prevail in the upper slope, while bedform fields become dominant further downslope. Instability is also widespread as indicated by numerous landslide scars. (b) A detailed image of sediment waves in the offshore of Piscità, where a channel (Piscità ch) develops in the northern slope of Stromboli volcanic edifice. (c) Bathymetric map of the Sicilian margin in the area of the Cefalù Basin. A channel-levee complex develops at the base of slope and is affected by widespread seafloor instability. The related landslide and debris flow deposits (areas in pink) form chaotic bodies that can reach the basin plain forming lobes. (d) A side scan sonar image of part of the Capo d'Orlando channel-levee complex. It shows the complex nature of the landslide scars, the blocky facies of the landslide deposits, which sometimes plug the channels. The corresponding sub-bottom profile shows that the landslide deposits have a chaotic facies and lie on top of a levee wedge with continuous reflections.

2(a)). The oldest rocks found in the Aeolian Archipelago, dated at 1.3 Ma, were sampled from the Sisifo Seamount (Beccaluva et al., 1982).

Subaerial volcanism started at 270–250 ka on Salina, Filicudi and Lipari islands and is still active at Lipari (AD 1230), Vulcano (AD 1888–1890) and Stromboli (Rosi et al., 2000). The volcanic rocks belong to the calc-alkaline, HK-calc-alkaline, shoshonitic and alkaline potassic series (Barberi et al., 1974).

The Aeolian Arc has three sectors characterized by distinctive structural trends and evolution (Figure 1 (a); De Astis et al., 2003; Gamberi et al., 1997; Romagnoli, Casalbore, Bortoluzzi, et al., 2013; Ventura, 2013).

The western sector is mostly controlled by the Sisifo-Alicudi fault System, WNW-ESE-oriented strike-slip dextral shear zone (Bortoluzzi et al., 2010), showing that conjugate synthetic and antithetic fault systems, mainly trending WNW-ESE and NNE-SSW, have controlled the magmatism (Figure 1(a)). The central sector lies along the northern termination of the Aeolian-Tindari-Letojanni Fault System and is mostly dominated by volcanic and tectonic features along a NNW-SSE-trending belt extending from the northern Sicilian coast to Salina Island (Argnani et al., 2007; Ventura, 2013; Figure 1(a)). The eastern sector, along the Stromboli-Panarea Fault System is characterized by prevailing NNE-SSW to NE-SW striking fault systems that control vents and eruptive features on Panarea and Stromboli Islands (Francalanci et al., 2013; Ventura, 2013) and in the submarine areas (Gamberi et al., 1997; Romagnoli, Casalbore, Bortoluzzi, et al., 2013; Figure 1(a)).

3. Methods and software

As the maps were produced using the specific interpretative and cartographic standard used in the MAGIC project, the procedure is described in detail in Ridente and Chiocci (this volume). The legend of the Physiographic Domain map is presented on the map. The legend of the maps of the 'Morphological Units and Morpho-bathymetric Elements' is presented as a separate table.

4. Maps of morphologic units and morpho-bathymetric elements

4.1. Stromboli Area (MaGIC sheet 16)

The Sheet 16 'Stromboli' includes the submarine portions of Stromboli and Panarea edifices and has regional tectonic structures with SW-NE direction (De Astis et al., 2003).

Stromboli is a steep, andesitic-basaltic stratovolcano, whose submarine part accounts for about 98% of its surface. The edifice is made up of two volcanic centers: Stromboli, developed in the last 100 ka and Strombolicchio, dated at 200 ka (Gillot & Keller, 1993). The base of the edifice is located between 1400 and 2700 m depth. Stromboli displays a marked bilateral symmetry with respect to the main SW-NE axial zone (Bosman et al., 2009; Casalbore, Romagnoli, et al., 2011; Tibaldi et al., 2009), where most of the dykes, vent and eruptive fissures are present (Pasquarè et al., 1993). The SW and NE flanks are characterized by large insular shelves. In contrast, the NW and E flanks are affected by multiple sector collapses that led to the development of large subaerial-submarine depressions down to 500–700 m water depth and to the emplacement of debris avalanche deposits in the more distal flanks (Romagnoli, Kokelaar, et al., 2009 and Romagnoli, Casalbore, et al., 2009). In 2002, a tsunamigenic submarine landslide occurred on the submarine and subaerial slope of the Sciara del Fuoco (Chiocci et al., 2008). The monitoring of the 2002 scar shows its rapid infill that partially obliterated its original morphology (Casalbore et al., 2012). On February 2007, a new eruptive crisis led to the emplacement of a large lava delta within the 2002 scar, with a maximum thickness of 70 m and volume of 10×10^6 m^3 (Bosman et al., 2014), with implications on the slope stability (Casalbore, Passeri, et al., 2020). Subsequent volcanic activity (such as in 2014, 2019–2020, 2021) was responsible for the formation of further lava deltas at the foot of the subaerial Sciara del Fuoco, largely reworked during phases of reduced activity (Casalbore, Di Traglia, et al., 2021). Subaerial and submarine slope accretion and erosion occur through time, also in association to pyroclastic flows occurrence and small-scale instability processes continuously reshaping the slope (Casalbore et al., 2022; Di Traglia et al., 2022).

A volcaniclastic apron surrounds the volcanic edifice. It consists of a large spectrum of geomorphic elements, such as slide scars and related deposits, channels and bedforms (corresponding to 90% of the entire area), alternated with volcanic outcrops (Casalbore et al., 2010).

The Panarea edifice is 2000-m-high and displays a large insular shelf, with a diameter of 8 km and outer edge at 120–150 m depth, which is representative of the maximum subaerial extension reached by the subaerial volcanic edifice (Romagnoli, 2013). The insular shelf is covered by submarine depositional terraces, i.e. sedimentary wedges with internal prograding geometry, whose formation occurs below the storm-wave base level (Casalbore, Falese, et al., 2017 and reference therein). The shallow-water portions of Panarea are affected by tectonic and hydrothermal activity (Gamberi et al., 1997). In 2002–2003, a strong degassing activity on the shelf offshore the islets facing the eastern part of Panarea Island was responsible for a large plume of suspended sediments at the sea surface (Esposito et al., 2006).

In the slope, the flanks of both volcanoes are steep and uneven, with volcanic outcrops alternated with features such as channels, landslide scars and extensive bedform fields (Casalbore et al., 2014; Romagnoli, Casalbore, Bortoluzzi, et al., 2013). Finally, part of the Stromboli Canyon is present in the westernmost sector of the sheet. It represents the main feature of the southern Tyrrhenian Sea with a length of about 120 km (Gamberi & Marani, 2007; Gamberi & Marani, 2011).

4.2. Milazzo Area (MaGIC sheet 17)

The western sector of the Sheet 17 'Milazzo' is the site of a channel-levee system built by the Milazzo, Villafranca and Niceto submarine channels (Gamberi et al., 2013; Hansen et al., 2015). The channels connect upslope with canyons with their heads close to the coastline (Gamberi, 2020; Gamberi et al., 2015, 2017).

The Milazzo slope channel is the proximal trunk of the Stromboli Valley. The Niceto Channel also connects with the Stromboli Valley and has an eastern levee hosting 50-m-high sediment waves (Hansen et al., 2015).

The Villafranca Channel forms and connects to a transient fan lobe, with an area of 225 km^2 (Gamberi, Rovere, Mercorella, Leidi, 2014; Gamberi & Rovere, 2011).

The south-western sector of the sheet, offshore from the town of Milazzo, displays various canyons directly connected to rivers (Gamberi, Rovere, Mercorella, & Leidi, 2014). The canyon heads indent the shelf, being extremely close (less than 500 m) to an industrial area, posing a serious hazard on the infrastructures, in the case of retrogressive canyon-head instability. In addition, hyperpycnal flows triggered by extreme climate events, such as that connected with a flood in 2011, that hit several municipalities, including Barcellona Pozzo di Gotto, are further processes with strong erosional behavior, sources of serious geohazards.

To the West from the channel-levee system, in the eastern sector of the sheet, a large mass-transport complex develops on the western slope of the Acquarone Ridge, a structural high formed as a horst during the rifting of the northern Sicily margin (Gamberi et al., 2011; Gamberi et al., 2020; Gamberi & Marani, 2006). The mass-transport complex was formed during several distinct episodes of seafloor instability which deposited different bodies, the largest being the 230 km^2 Villafranca Slide, which is 300-m-thick, with an estimated volume of 48 km^3 (Gamberi et al., 2011; Rovere et al., 2014). On top of the Acquarone Ridge, a field of pockmarks is the evidence of fluid circulation and flow, which may contribute to the instability along the slope (Rovere et al., 2014).

4.3. Capo d'Orlando Area (MaGIC sheet 18)

The Sheet 18 'Capo D'Orlando' includes the north-eastern Sicilian continental margin in the area between the Gulf of Patti and Capo d'Orlando, as well as the submarine portions of Vulcano, Stromboli and Salina volcanic edifices. The area has a narrow (up to 6-km-wide) and steep shelf, whose edge is deeply indented by canyons (Gamberi, 2020; Gamberi et al., 2017). Most of the canyon heads are located at less than 50 m of depth, only a few hundreds of meters from the coast (Casalbore, Clementucci, et al., 2020; Chiocci & Casalbore, 2017; Gamberi, 2020; Gamberi et al., 2015). Moreover, a large submarine deltaic system is present off the mouth of Mazzarrà River, with gullies and seafloor waveforms (Casalbore, Ridente, et al., 2017). Specifically, the gullies are the erosive trace of hyperpycnal flood generated during flash-flood as observed in similar setting elsewhere (Casalbore, Chiocci, et al., 2011; Chiocci & Casalbore, 2011).

The canyon heads consist of several coalescing and retrogressive slide scars, having average diameter of few hundreds of meters. Canyons drain the entire continental slope over 1000 m depth and are ten kilometers long, some hundreds of meters wide and up to 100-m-deep (Gamberi, 2019; Gamberi et al., 2015).

The Vulcano, Lipari and Salina volcanic edifices have been strongly controlled by a main, NNW-SSE-trending strike-slip fault system, interpreted as the offshore prolongation of the regional 'Tindari – Letojanni' fault in north-eastern Sicily and showing right-lateral to oblique kinematics (Romagnoli et al., 1989; Ventura, 2013). Insular shelves, with a maximum width of 2 km, develop around the oldest part of the volcanic edifices. The edge of these shelves is located between 90 and 220 m depth (Casalbore, Bosman, Romagnoli, Di Filippo, et al., 2016; Casalbore, Bosman, Romagnoli, & Chiocci, 2016; Romagnoli, 2013; Romagnoli, Casalbore, Bosman, et al., 2013), approximately corresponding to the lowermost level reached by sea level during the Late-Quaternary sea level fluctuations (Bintanja et al., 2005). The areas where the shelf edge is deeper were affected by subsidence after their formation (Romagnoli et al., 2018). The insular shelf edge is frequently the seat of shallow landslides scars, as observed at Stromboli (Casalbore, Romagnoli, et al., 2011), and their possible (re)activation may potentially generate tsunamis. At greater depths, the volcanic flanks are steep (slope gradients >30°) and uneven, due to volcanic outcrops and geomorphic elements with both erosional and depositional genesis (Casalbore et al., 2014). Volcanic outcrops occur both near the coast, in continuation with subaerial structures, and as isolated features on the submarine flanks, unrelated to the subaerial morphology. The erosive and depositional sedimentary features include channels, depositional fans, bedforms and landslide scars (Casalbore, Clare, et al., 2021; Gamberi, 2001; Romagnoli, Casalbore, Bortoluzzi, et al., 2013). Specifically, the submarine part of La Fossa Caldera at Vulcano (Casalbore et al., 2018; Romagnoli et al., 2012) and the submarine canyons in the eastern part of Lipari (Bosman et al., 2015; Casalbore, Romagnoli, et al., 2017c) are the seat of active canyons with headwalls approaching the coast and represent a main potential geohazard for coastal areas.

In the eastern coastal area of Lipari,, a significant subsidence since roman times has been shown (Anzidei et al., 2016) and this, together with the coastal dynamics occurred in the last decades (Romagnoli et al., 2022) can have severe implications for flooding scenario in the most touristic part of the island (Anzidei et al., 2017).

4.4. Alicudi e Filicudi Area (MaGIC sheet 19)

The Sheet 19 'Alicudi e Filicudi' includes the western part of the Aeolian arc, with the homonymous islands, and a submerged portion, consisting of Eolo and Enarete seamounts and the volcanic range comprising Sisifo Seamount (Marani & Gamberi, 2004b). To the south of Eolo seamount and the islands of Filicudi and Alicudi. The northern part of the Cefalù Basin is also part of the sheet.

The island of Filicudi stretches in a NW-SE direction. The oldest basalts and andesites of the island, are dated 200 ka (Barberi et al., 1994). In the northwestern sector, an additional distinct volcanic edifice is present; it has a flat top peaking at 50 m depth. The flat morphology of the edifice is probably the result of repeated marine abrasion during low sea-level stands. The southern part of Filicudi is located at the northern margin of the flat basin plain of the Cefalù Basin, at 1500 m depth; its northern slope drops to 1750 m and is traversed by a wide erosional chute delimited. The feature extends from the shallow water down to the base of the edifice. A flat-lying seafloor surrounds the island, except for its northern sector. An area of rugged seafloor topography, 10 km NE of the island, is a further indication of submarine volcanism.

The oldest basalts and andesites of the island of Alicudi, are 167 ka (Villari, 1980). Alicudi is a near-perfect cone with a circular base at the northern margin of the Cefalù Basin plain at 1500 m depth. The flat plain continues to the North of the island as a 10-km-long, 5-km-wide bench delimited by a 500-m-high western escarpment. The eastern margin has a relief of about 250 m before merging with the products of Filicudi Volcano. Several minor volcanic constructions develop at the rims of the bench to the north of Alicudi. In particular, a 500-m-high conical volcano stands out at the north-eastern termination of the bench.

Eolo Seamount is located 20 km westward from Alicudi Island in the western margin of the sheet. Dredge hauls from Eolo have included basalts, dacites and rhyolites, dated between 0.85 and 0.77 Ma (Beccaluva et al., 1985). The volcano has a wide, 3 km by 2 km, relatively flat summit area, ~800 m deep, elongated in an NW-SE direction (Marani & Gamberi, 2004b). The flat summit of Eolo Seamount is roughly square-shaped and is bounded by linear highs (75–125-m-high) on three sides, except to the SW. In this latter side, the summit area terminates at a 300-m-deep scarp surrounded by three small cones (350-, 250- and 175-m-high), which thus form a closed depression. A conjecture could interpret the flat lying summit surrounded by highs, as an infilled caldera, implying the destruction of a previously larger edifice.

4.5. Sisifo-Enarete Area (MaGIC sheet 20)

The Sheet 20 'Sisifo-Enarete' encompasses the western sector of the Aeolian Arc, including from the east, a small portion of Eolo and the submarine volcanoes Enarete, Enaretino and Sisifo (Marani & Gamberi, 2004b). In addition, in its southern part, the north-western portion of the Cefalù Basin, at approximately 1700 m depth, is part of the sheet. The area becomes deeper northward, in the Enarete and the Sisifo basins, which are located in the NE and in the NW corners, respectively; these are separated by the volcanic edifice of Sisifo and reach the depth of 2800 m (Marani & Gamberi, 2004b).

Sisifo is am NW-SE-directed, 20-km-long, ridge, bordered by faults along its southern flank. The volcanic edifice consists of basalts and trachytes dated 1.3–0.9 Ma (Beccaluva et al., 1985), thus holding the oldest age in the Aeolian Arc.

Enarete, on the contrary, is cone-shaped, slightly NW-SE elongated, with a northern flank characterized by gullies and ridges formed by gravity flows originated from the summit areas (Marani & Gamberi, 2004b). The Enarete Volcano, which reaches up to a minimum depth of 300 m, is formed by basalts dated 0.78–0.67 Ma (Beccaluva et al., 1985); small volcanic cones are located in its western and southern flanks. Sediment and rock sampling on the summit area of the volcano showed hydrothermal activity, consisting of recent deposits of manganese oxides and hydro-oxides (Marani et al., 1999). About 3 km westward of Enarete, a small coalescing cone stands up for a few hundred meters. Another small volcano, tentatively named Enaretino, is located 6 km to the East of Sisifo; it is up to 1000-m-high over the flat area of the Enarete Basin (Marani & Gamberi, 2004b).

A vast lava flow outcrops or sub-crops in the western part of the sheet, between Enarete and Sisifo.

The flow is possibly fed by volcanic edifices (vent) located in the south-western area of the sheet.

4.6. Sant' Agata di Militello Area (MaGIC sheet 23)

The area of the Sheet 23 'Sant'Agata di Militello' is located along the northern Sicilian margin, between Capo d'Orlando and Finale. The sheet Sant'Agata includes the continental shelf and slope and a portion of the basin plain of the Cefalù Basin at about 1500 m depth. The continental shelf has its maximum width of about 12 km in the central part of the sheet and narrows to only 5 m toward both the eastern and western margins. The shelf-break is located between 140 and 150 m depth; lower depths coincide with the heads of the canyons (Gamberi, 2019; Gamberi, 2020; Gamberi et al., 2015). In particular, in the westernmost area, the heads of the Zappulla and Orlando canyons are very close to the coast; here, the shelf has a reduced width (less than 500 m) and the shelf-break is consequently located at a very shallow depth (Gamberi et al., 2015).

The coastal systems are fed by torrential rivers, that, when reaching the sea, originate hyperpycnal flows and build deltas, which submerged part is present in the areas closest to the coast and thus not imaged in the acquired data. The distal parts of the modern coastal systems, characterized mainly by a uniform drape of sediment of the Holocene prograding wedge, are present in the inner continental shelf. The external shelf, in particular in its central and widest part, displays basement highs and relict morphologies above the erosional surface formed during the subaerial exposure in the last sea-level lowstand. Depositional bodies originated during the successive transgression of sea level crop out as relict geomorphic elements, such as spits, tombolos, deltas, coastal barrier-lagoon systems.

A series of canyons, chutes and gullies incises the upper continental slope. The largest canyons are present in the eastern part of the sheet, where the head of the Orlando Canyon is imaged at only 30 m depth, only 500 m from the coastline. The head of the Zappulla Canyon is at only 2 km from the coastline. Large canyons also develop in the western part of the sheet (Gamberi et al., 2015). In this area, canyons are associated with extensional faults. This area is also affected by widespread instability with mass-transport complexes, with mainly a blocky texture (Gamberi, 2019; Gamberi et al., 2015; Gamberi & Dalla Valle, 2009). In the lower slope, the Orlando and Zappulla canyons connect to leveed channels (Gamberi, 2019; Gamberi et al., 2015). Widespread instability processes at different scales affect the depositional levees (Gamberi, 2019). Where the channels reach the basin plain, frontal splays span the whole basin plain; they reach the northern edge of the basin to the north of the limit of the sheet (Gamberi et al., 2015).

5. Conclusions

The area of the Aeolian volcanic arc and of the north-eastern Sicilian margin has a complex morphology due to the interplay between volcanic, tectonic and sedimentary processes, at different spatial and temporal scales. The morphologic analysis has evidenced various offshore geohazard elements, among which submarine landslides affect both the submarine slope of the Aeolian Island and the Sicilian margin. Large-scale landslides, linked to sector collapse, affected Stromboli and destroyed large portions of the subaerial and submarine edifice. A more important threat is associated with smaller scale, more frequent failures, as shown by the Stromboli 2002 event, connected with a volcanic unrest on land. In these cases, besides landslides, an equally important hazard, stems from the possible generation of tsunamis, which can impact the coastal areas. Landslides are the major geohazard also in the Sicilian continental margin. They occur as large mass-transport complexes, which affect the margin, such in the Gioia and in the Cefalù Basin, with headwall regions located in general far from the coast. In these cases, they result from the stacking of various landslide bodies, proving that seafloor instability is a recurrent event. As in the volcanic slopes, landslides along the Sicilian margin can however also occur as the result of smaller scale failures at the head of submarine canyons. This kind of collapse, although involving a relatively small volume of sediment, can have a significant impact particularly where canyon heads are close to the coast, a frequent setting in the study area, both in the Aeolian Island submarine flanks and in the Sicilian north-eastern continental slope.

Software

Global mapper and IHS Kingdom suite were used for bathymetric and seismic data visualization and interpretation.

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Data availability statement

Data will be made available by the authors upon reasonable request.

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